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95 S.W. and 95 S.E.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

EXPLANATION OF QUARTER-SHEETS 95 S.W. AND 95 S.E. OF THE
ONE-INCH GEOLOGICAL SURVEY MAP OF ENGLAND,

ILLUSTRATING

THE GEOLOGY

OF

THE OOLITIC AND CRETACEOUS ROCKS SOUTH OF SCARBOROUGH.

BY

C. FOX-STRANGWAYS, F.G.S.

BIBLIOTHECA
JUL 1880
BODLEIANA

THE LISTS OF FOSSILS REVISED BY R. ETHERIDGE, F.R.S.

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NOTICE.

THE formations included in the district described in this Memoir consist of Oolitic, Cretaceous, Glacial, and Post-Glacial strata. It is well known that in the Yorkshire area both the Oolitic, or Jurassic, and the Cretaceous strata differ in many particulars from a great part of the formations of the same age in the middle and south of England. It may help those who are unfamiliar with such details to state, that the Lower Oolites of Yorkshire, as shown in page 3, largely consist of Estuarine strata, whereas, in the south of England the various sub-divisions are certainly of Marine origin. The Cornbrash strata in both areas preserve the same Marine character.

In the midland and southern parts of England the Middle Jurassic strata in ascending order consist of Oxford Clay, Calcareous Grit, and Coral Rag, whereas in Yorkshire we find the same Oxford Clay with Kelloway beds near the base, overlaid by various interstratifications of Calcareous Grits and Limestones, above which lies the true Coral Rag.

In both regions the Kimeridge Clay is the same, while the Portland Sand and Limestone of the South is in Speeton Bay feebly represented by beds of Clay containing some of the fossils of the Portland strata.

There are differences also in the Cretaceous series.

The ordinary Chalk in both is much the same. Under the Lower White Chalk in Yorkshire, we find the Red Chalk the equivalent of the Hunstanton Limestone in Norfolk, which in its origin may possibly be as early as the Gault, and cannot be of later date than the Upper Greensand. Beneath the Red Chalk there lies the Speeton Clay, which, in this district, rests directly upon the Upper Oolitic strata. The Speeton Clay in old times was supposed to represent the Gault. This formation has, by Professor Judd, been correlated with the Continental Neocomian series, and therefore, in this region it represents under a different lithological character the strata of the Lower Greensand and Atherfield Clay, and also all the Freshwater and Estuarine beds of the Wealden series.

From the foregoing statements it is evident that the differences between the Lower Oolites in the South and in Yorkshire, are owing to difference of conditions in the Physical Geography of the areas at the time of the deposition of the strata, for whereas in the South, the rocks are almost exclusively of Marine origin, in the Yorkshire area we find a Lower Estuarine series overlaid by the Marine Millepore group of strata containing most of the Inferior Oolitic Mollusca, &c. This Marine bed is in turn overlaid by a second set of Estuarine beds, above which there lies the Scarborough or Grey Limestone with Inferior Oolite fossils, between which and the Cornbrash there occurs a third or uppermost series of Estuarine strata.

Beds of Coal are found in the Middle Estuarine series lying on the soils on which the plants grew. From the decay of these plants the beds of Coal were formed, in a manner similar to the formation of the Coal of the Coal-measures. It is therefore plain that in the North during this epoch, Marine, Estuarine, and Terrestrial conditions alternated for a long period of time, while in the Midland and Southern counties the conditions under which equivalent formations were formed were entirely Marine.

ANDREW C. RAMSAY,
Director General.

NOTICE.

The area comprised in the Quarter-sheets 95 S.W. and S.E. of the Geological Survey Map of England and Wales contains the important watering places of Scarborough and Filey, and the magnificent promontory of Flamborough Head, and is occupied by the Jurassic, Cretaceous, and Quaternary deposits described in detail in the following pages.

The examination of the district and the compilation of this description were executed by Mr. Fox-Strangways, to whom much credit is due for his careful investigation of a district, very interesting in its geological features, much frequented by lovers of the beautiful in nature, and not entirely destitute of minerals of commercial value.

The nomenclature of the fossils has been determined by Mr. Etheridge. The lists show frequent changes of fauna, though often unaccompanied by important stratigraphical discontinuity.

H. W. Bristow,
Senior Director.

Geological Survey Office,
28 Jermyn Street, S.W.
20th December 1879.

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THE GEOLOGY

OF

THE OOLITIC AND CRETACEOUS ROCKS SOUTH OF SCARBOROUGH.

INTRODUCTION.

THESE few pages are intended to give a short sketch of the leading geological and physical features comprised in the Quarter-Sheets 95 S.W. and 95 S.E. of the one-inch Geological Survey Map of England and Wales.* A more detailed account of the Oolitic portion of these maps will be given in a general memoir on the Yorkshire Oolites.

These sheets contain a land area of about 216 square miles; the only towns of any importance situated within their limits are Scarborough and Filey, both of which are close to some of the most interesting sections on the Yorkshire coast.

With the exception of a narrow strip along the coast, almost the whole area is drained by the river Derwent through the gorge below Malton, and it is very remarkable how this river has cut its way southwards through two Oolitic barriers in preference to following the apparently direct and open valleys to the east. In the first of these cases the river has formed the picturesque gorge of the Forge Valley, although there is a larger and more direct passage to the coast through which a portion of the water is even now artificially conducted during floodtime into the sea at Scalby Ness: in the second instance the river has found its way through moderately elevated Oolitic strata south of Malton, while the present watershed to the east near Filey is not more than 130 feet above the sea, and but for the formation of some quite recent deposits the general slope of the valley would have been in that direction.

That portion of the map occupied by the Chalk, which from its porous nature has no perennial surface streams, probably divides its waters, a part issuing as springs along the Wold foot and joining the Derwent, another part finding its way along the gravels in the Wold valley into the sea at Bridlington Quay.

The principal physical features divide this area into three districts: northern, central and southern.

Firstly, along the northern portion of the map are hills of Oolitic limestone and sandstone, which, rising gradually to the north, form a line of bold escarpments west and south of Scarborough, and finally terminate in the projecting reef of Filey Brig.

---

* The part along the coast near Scarborough is also published on the scale of six inches to a mile. The numbers of the maps are 77, 78, 93, 94.

Secondly, the central district is formed by the broad flat valley through which the Derwent flows between Ayton and Malton, which in some places is not more than 60 feet above the sea level, and which, if the lacustrine deposits were removed, would be considerably below that level.

Thirdly, the range of hills which forms the northern scarp of the Chalk Wolds, rising to a height of 160 feet at Settrington Beacon, occupies the whole southern portion of the area occupied by these maps, and running out to sea for some distance forms the bold headland of Flamborough.

In this district we have an instance of how the geological structure of the country has influenced the selection of the sites of most of the villages. These almost all lie on either edge of the great clay valley, where springs of beautiful calcareous water burst out; thus on the north are Wilton, Allerston, Ebberston, Snainton, Brompton, Wykeham, Hutton Buschel, Ayton and Seamer, while to the north are Rillington, Thorpe Basset, Wintringham, Heslerton, Sherburn, Ganton, Staxton, Flixton, Folkton, Hunmanby, and several smaller hamlets.

GEOLOGICAL FORMATIONS.

The following formations are described in this Memoir:—

Recent and Post-glacial		Recent Alluvium.
		Gravels of dry Chalk and Oolitic Valleys.
		Peat.
		Warp and Lacustrine Clay.
		Sands and Gravel (Estuarine and Subaerial).
Glacial - - -		Boulder Clay, Sand and Gravel.
		Old Chalk Gravel.
Upper Cretaceous -		White Chalk.
		Red Chalk.
Lower Cretaceous -		Upper Neocomian Clays.
		Middle ,, ,,
		Lower ,, ,,
Upper Oolite - -		Portland Beds.
		Kimeridge Clay.
Middle Oolite - -		Upper Calcareous Grit (uncertain).
	Coralline Oolite	Upper Limestone (Coral Rag).
		Middle Calcareous Grit.
		Lower Limestone.
		Greystone or Passage Beds.
		Lower Calcareous Grit.
		Oxford Clay.
		Kellaways Rock.

Lower Oolite - -	Cornbrash.	
	Inferior Oolite	Upper Estuarine Series.*
		Scarborough or Grey Limestone Series.
		Middle Estuarine Series.
		Millepore Series.
		Lower Estuarine Series.

Lower Oolites.

The Lower Oolite consists of a great alternating series of estuarine, marine, and freshwater beds. The total thickness of these beds shown in the map is over 300 feet, but below this there is a considerable thickness of measures which do not outcrop in this area, but which are well seen further north in the cliffs about Staintondale.

These measures are divisible into three estuarine series, each of which is capped by a thin but well-marked band full of marine fossils.

Lower Estuarine Series.—The lowest beds that appear in the map are some irregular but tolerably massive sandstones which are seen only at low tide along the furthest part of the reefs opposite Yons Nab,† and Carnelian Bay. At the first of these places there are two or three reefs of this sandstone, but they are only exposed at very low water. In Carnelian Bay these beds have their largest exposure, being brought up by the fault which traverses the bay, and the course of which is well seen by the disturbance it causes to the sandstones on either side. At neither of these places is there a very great thickness exposed, but the rocks appear to have become excessively hard and well able to withstand the force of the sea.

Millepore Series.—These, which are the lowest marine beds exposed in this part of the country, have received their name from the little bryozoan *Spiropora* (*Millepora*) *straminea*, Phil., the fragments of which in some places occur in great numbers on the surface of the rock.

On the coast this rock is not a true limestone, but has more the nature of a very hard and siliceous calcareous sandstone with ferruginous partings, in fact the exposed situations which it occupies on the shore, and the manner in which it forms as it were a breakwater to the softer strata behind, testify to its extremely hard nature. It is a false-bedded partly oolitic rock, full of the remains of Crinoids in a fragmentary condition, and has every aspect of having been formed in comparatively shallow water. Resting on this hard rock at Yons Nab are a series of marly shales with a few ferruginous bands and some sandstone, which, on account of the fossils that they contain, must be included in

---

[*] These must not be confounded with the "Upper Estuarine Series" of the Great Oolite of Rutland, Lincolnshire.

[†] The Ordnance names are used in this Memoir; the local names are frequently different. Mr. Hudleston informs me that the old name of this place was Yown, or Oven Nab.

this group; they are nevertheless very different from the main mass of the Millepore Series. This upper portion is very local, and has been only observed on the south side of Cayton Bay, where the following section was measured:—

	ft.	in.
Ferruginous sandstone with *Trigonia signata, Avicula, Myacites*, &c.	4	0
Sandy shale with an ironstone band near the base	4	6
Ferruginous band containing *Pecten clathratus, Pecten articulatus, Avicula Braamburiensis, Pholadomya Heraultii, Ostrea*, &c.	1	0
Sandy shales with fossils in upper part and ripple marks about half way down: *Trigonia* very abundant in this bed, which also contains *Aviculæ*, spines of *Pseudodiadema*, and remains of plants	7	0
Measures indistinctly seen, principally marly shales, about	8	6
Total	25	0

Below this occur about 15 feet of hard calcareous sandstone with *Spiropora straminea*, the true Millepore bed, forming a reef of rocks extending from the Point across Gristhorpe Bay to the Old Horse rocks.

At Osgodby Nab* the upper or softer portion of the series seems to be absent, although it may be represented by some 10 or 12 feet of ferruginous sandstone, but as this sandstone appears to be entirely unfossiliferous, it is impossible to offer an opinion. The true Millepore bed at this place has a maximum thickness of about 20 feet, and is very similar to that in Gristhorpe Bay, the fallen blocks forming a magnificent natural protection to the Point.

The most characteristic fossils of the Millepore series on the coast are:—†

POLYZOA.

Spiropora (Millepora) straminea, Phil.

ECHINODERMATA.

Pygaster semisulcatus, Phil.
Stomechinus germinans, Phil.

LAMELLIBRANCHIATA.

Pecten demissus, Phil.
Pinna cuneata, Bean.
Lima duplicata, Sow.
Gervillia lata, Phil.
Modiola imbricata, Sow.
Unicardium gibbosum, Lyc.
Goniomya literata, Sow.

---

* Professor Phillips describes this headland under the name Ewe Nab.

† This and the following lists of fossils have been compiled by Mr. Etheridge. More exhaustive lists will be published in the general Memoir on the Yorkshire Oolites.

Trigonia recticosta, Lyc.
„ *conjungens*, Phil.
Pholadomya Heraultii, Ag.
„ *Sæmanni*, L. & M.
Ceromya Bajociana, D'Orb.

GASTEROPODA.

Natica adducta, Phil.
Chemnitzia vetusta, Phil.
Actæonina glabra, Phil.
Cerithium Leckenbyi, Wr.

Middle Estuarine Series.—These beds rest directly on the Millepore Series, and are not seen anywhere except in the two localities just mentioned, but as their lithological character at these two places is so very different it will be better to describe them separately.

At Yons Nab there are an alternating series of thin bands of sandstone and shale with thin streaks of coal, which occupy most of the cliff and foreshore at this place. These beds have been described in detail by Professor Phillips, Dr. Wright,* and others, but as there is a slight difference in the relative thicknesses on either side of the point, and a considerable difference in the results obtained by different authors, we give the absolute measurements at both places.

SECTION measured EAST of the POINT in GRISTHORPE BAY.

	ft.	in.
Sandstone with fine black laminations, very characteristic - - - -	5	0
Shale - - - - -	8	0
Black coaly shale - - - -	0	3
Soft white sandstone, with rootlets - -	1	0
Grey shale - - - - - -	5	0
Sandstone and shale with carbonaceous markings, and some sulphur - -	3	6
Black shale - - - -	1	6
Finely laminated sandstone - -	1	6
Finely laminated shale, with irregular patches of coal and fossil plants - - -	6	0
False-bedded sandstone, with pyrites and carbonized wood, passing into hard sandstone towards the base - - -	21	0†
Total -	52	9

---

* Quart. Journ. Geol. Soc., Vol. XIV., p. 89, and Vol. XVI., p. 30. Professor Phillips' Geology of the Yorkshire Coast, 3rd edition, p. 114. There is also an admirable paper by my friend Mr. W. H. Hudleston, published in the Proceedings of the Geologists Association, Vol. III. This last gives a most detailed account of the whole of the Lower Oolites on the coast, and of several of the inland localities.

† The greater part of this bed probably belongs to the upper portion of the Millepore Series, although no fossils were observed at this point.

SECTION measured WEST of the POINT, LOW RED CLIFF.

	ft.	in.
Laminated sandstone - - -	4	6
Shale - - - - -	6	0
Sandstone - - - - -	1	0
Shale - - - - -	2	0
Sandstone, with rootlets and coaly streaks -	3	0
Irregular sandstone and shale - -	2	0
Sandstone - - - - -	2	0
Shale. Thin irregular ironstone band near the top - - - - -	2	0
Sandstone with carbonaceous markings. Plant bed? - - - -	2	0
Shale - - - - -	3	6
Massive sandstone - - - -	4	0
Shaly sandstone - - - -	2	0
Total -	34	0

In the shales just over the thick sandstones in the lower part of the first of these sections the celebrated Plant bed of Gristhorpe occurs, which has afforded so rich a harvest to the Palæobotanist.*

LIST of FOSSIL PLANTS found in GRISTHORPE BAY.

Taxites laxus, Phil.
Walchia Williamsonis, Brong.
Tœniopteris vittata, Brong.
„ *major*, Lindley.
Hymenophyllites Williamsonis, Brong.
Sphœnopteris denticulata, Brong.
Glossopteris Phillipsii, Brong.
Phlebopteris polypodioides, Brong.
„ *Phillipsii*, Brong.
Pecopteris dentata, Lindley.
„ *lobifolia*, Phil.
Ctenis falcata, Lindley.
Odontopteris Leckenbyi, Zign.
Otozamites Beanii, Lindley.
Pterophyllum pecten, Lindley.
„ *comptum*, Lindley.
Equisetites columnaris, Brong.

The place of these rocks at Osgodby Nab is occupied by a soft yellow ferruginous sandstone, which is tolerably uniform in composition; there are about 50 feet seen altogether at this place, but the top has been denuded off before the deposition of the Boulder-Clay. The lower portion of the sandstone is more ferruginous than the upper; and as we have said above, it is an undecided point whether they should be mapped with the Millepore Series or not, but in the total absence of fossils we prefer to class them here.

---

* A list of these plants is given, and several of the species figured, by Leckenby, Quart. Journ. Geol. Soc., Vol. XX., p. 76, and by Phillips, Geology of Yorkshire, 3rd edition, chap. XV.

The Scarborough or Grey Limestone Series.—These beds are much in want of a good descriptive name; they are scarcely solid and compact enough to deserve the name of limestone, at the same time the greater part of them is too calcareous to be true shale.*

Their thickness, like most of the other subdivisions of the Lower Oolites, increases towards the north and west; thus in Gristhorpe Bay they are not more than from 3 to 7 feet thick, whereas at White Nab they are at least 20 feet, although the base of the rock is not seen, and in the next map north of Scarborough at Cloughton Wyke they have increased to nearly 70 feet.

In Gristhorpe Bay this horizon is represented by a thin bed of shale and a little ironstone, which would be very difficult to trace across the low water scars if it were not for the bed of finely laminated sandstone below, which is beautifully interstratified with thin carbonaceous seams in quite a characteristic manner, and forms a well-marked reef throughout the length of the bay; at the western end of the bay these beds rise in the cliff, and there is obtained a much better view of them. They here have a thickness of 6 feet 10 inches, and consist of grey crumbly shale, crowded in the lower part with *Avicula Braamburiensis, Ostrea flabelloides*, and other fossils, separated by two bands of hard impure ironstone nodules.

The following section was measured in the cliff:—

	ft.	in.
Hard grey ironstone - - -	0	10
Shale with fossils - - - -	1	6
Hard ironstone with fossils - - -	0	6
Shale full of fossils - - - -	4	0
Total -	6	10

This bed is seen again in the cliff and on the shore on the northern side of the point close to where it is cut by the great fault at Red Cliff, but the connexion between these two places is obscured by drift.†

The thickness of the beds at this place are—

	ft.	in.
Ironstone - - - - -	1	0
Shale - - - - -	1	6
Ironstone - - - - -	0	4
Shale full of fossils - - - -	2	0
Ironstone - - - - -	0	6
Black shale with sulphur - - -	2	0
Total -	7	4

Beyond the Red Cliff fault the Grey Limestone is next seen in Cayton Bay at Calf Allen rocks, where it forms the outermost portion of the island that is exposed at low water and from which we obtained *Avicula Braamburiensis, Myacites Scarburgensis,* and a small *Lima.*

---

* The name "Pier Stone" has been applied to these beds from the fact of the harbour pier at Scarborough having been built principally of blocks of this rock.

† Professor Phillips considered that the outcrop between these two places was concealed by the overlap of the beds above, but this appears very doubtful; it is more probable that the outcrop is concealed by drift, and not that there is any real unconformity.

Between the faults at Osgodby Nab this rock again crops up, and is seen on the shore on the south side of the point, but it is so jammed or thrust in between the faults, and so mixed up with the Oxford Clay, Cornbrash, and other rocks which have apparently slipped over it, that its outcrop is very obscure, and it is difficult to make out how far it extends.

At White Nab these beds again come up and occupy the shore nearly as far as the Spa at Scarborough, opposite to which it has a thin covering of sandstone; a little further on they are thrown up by a sharp roll and appear at the northern end of Ramsdale Scar in front of the Grand Hotel, which is the last that is seen of them in this map.

The beds at White Nab are harder and more ferruginous than those in Gristhorpe Bay, and contain *Gervillia acuta* in great abundance. The harder beds of rock from the shore at this place are occasionally used as a road material.

Inland the Grey Limestone does not come to the surface in this map, but a borehole has lately been sunk at the new Laundry near Seamer Lane, Scarborough, which appears to have penetrated the entire series, although it is not easy without more complete evidence to define the limits of strata belonging to this horizon. This section, which is the only one of those in Scarborough of which we have been able to obtain the details, is of particular interest as it occurs about midway between the exposures at Gristhorpe and Cloughton, at which places the measures are known to have so great a difference in thickness.

BOREHOLE at the NEW LAUNDRY, SEAMER LANE, SCARBOROUGH.

	ft.	in.
Clay	20	0
Rock (said to be like consolidated gravel)	52	0
Yellow clay	18	0
Sandstone	20	0
Blue rock	13	0
Blue clay	7	0
Blue rock	40	0
Black clay	10	0
Blue rock	6	0
Blue clay	4	0
Blue rock	10	0
Black and blue clay	10	0
Limestone (very hard, lighter colour than the measures above)	4	0
Light-coloured clay	6	0
Hard rock with limestone	55	0
Blue clay	5	0
Rock	10	0
Hard blue rock	10	0
White soft clay	12	0
Total	312	0

It is unfortunately not very clear from the above which are really the fossiliferous beds, but from the position of the borehole we may be tolerably sure that the sandstone in the upper part represents the thick bed at the base of the Upper Estuarine Series. Below this sandstone fossils are said to have been obtained so that it is probable the Grey Limestone beds were entered about here and may have continued somewhere to about the base of the 40 feet of blue rock. In the lower part of the section it seems that a portion of the 55 feet of "hard rock with limestone" would represent the true Millepore bed, while the 4 feet of limestone above might be one of the irregular or lenticular bands which are seen at Cloughton in the lower part of the Middle Estuarine Series.

LIST of CHARACTERISTIC GREY LIMESTONE FOSSILS.

ANNELIDA.

Vermicularia nodus, Phil.

LAMELLIBRANCHIATA.

Avicula Braamburiensis, Phil.
Pecten lens, Sow.
Ostrea flabelloides, Lam.
Gervillia acuta, Sow.
Pteroperna plana, L. & M.
Modiola cuneata, Sow.
Cucullæa cancellata, Phil.
Trigonia costata, Sow.
   „ *signata*, Ag.
Unicardium depressum, Phil.
Pholadomya Heraultii, Ag.
Goniomya v.-scripta, Sow.
Astarte elegans, Sow.

GASTEROPODA.

Chemnitzia Scarburgensis, L. & M.

CEPHALOPODA.

Ammonites Blagdeni, Sow.
   „ *Humphresianus*, Sow.
Belemnites giganteus, Schlöth.

The Upper Estuarine Series.—This, which is the last or uppermost division of the great estuarine deposits, is, like the other members of this series, an irregular mass of sandstones and shales with a few thin ironstone bands and much carbonaceous matter. The sandstones predominate mostly in the lower part and are excessively falsebedded, large masses, 20 feet or more in thickness, frequently thinning out and passing into shale in as many feet horizontally. In the lower part of the cliff just south of White Nab, this irregularity of bedding is most striking; in the same block of sandstone the upper layers, which are nearly horizontal repose on others inclined at an angle of 30°; this irregularity of bedding produces most curious curves on the low-water scars north of Scarborough.

In the lower part of this series there is a well-marked band of granular ironstone nodules about a foot in thickness, which is well exposed on the shore in Gristhorpe and Carnelian Bays and in the cliffs north of Scarborough.

The upper portion of these measures is mostly shale with thin sandstones and can be well studied in the cliffs south of Scarborough or inland at the clay works near Falsgrave; at these works the sandstones and shales are all ground up together and form a most excellent material for making bricks and draining pipes.

The following section was measured at the western end of Gristhorpe Bay, and gives a total thickness of about 120 feet for these beds; further north, judging by the height of the cliff below Wheatcrofts, they must be about 220 feet in thickness :—

CLIFF SECTION measured in GRISTHORPE BAY.

	ft.	in.
Shale with two bands of thin sandstone - -	50	0
Strata probably shale but much obscured by landslips -	38	0
Beds mostly sandstone ; forms the first reef in the bay -	15	0
Granular ironstone band - - - -	1	0
Sandstone with coaly streaks and sulphur - -	20	0
Total -	124	0

These rocks occupy most of the low ground about Scarborough and extend up the valley of the Derwent into Troutsdale; but their greatest area is to the north beyond the limits of this map.

The following species of plants are found in these beds:—

Cyclopteris longifolia, Phil.
" *digitata*, Brong.
Baiera gracilis, Bunbury.
Solenites furcatus, Lindley.
Pecopteris acutifolia, Lindley.

Cornbrash.—This apparently insignificant bed, which is not more than a few feet in thickness, is nevertheless very constant and has obtained considerable notice from geologists, both on account of the beautiful preservation of its fossils and the great number of species it has yielded.

The lower part of this rock is a grey rubbly ironshot limestone, partially oolitic and very fossiliferous, the fossils being so compacted together that it is difficult to obtain one specimen without spoiling many others; above this are about 6 feet of finely laminated bluish grey shale containing *Avicula* *echinata*, *Gryphæa Stricklandi*, and other fossils,* the so-called "Clays of the Cornbrash" which pass gradually up into the yellow argillaceous base of the Kellaways Rock. The blue colour of these shales and the red ferruginous aspect of the band of limestone are a great assistance in tracing the Cornbrash inland and arrest the attention in places where it might otherwise be overlooked.

The Cornbrash is first seen at the Wyke north of Newbiggin and may be traced for some distance along Gristhorpe Cliff; at Red Cliff it is thrown down by the fault and appears on the shore a little below high-water mark; at the northern end of Cayton Bay it appears again on the shore, but may easily be overlooked if at all concealed by sand. It is much disturbed by the faults at this place so that it is very difficult to distinguish this rock from the somewhat similar Grey Limestone.

From the position of the rocks above, the Cornbrash should outcrop somewhere at the southern end of Carnelian Bay, but at the time of our survey it was entirely concealed by the enormous masses of Boulder Clay.† Further north it outcrops again at the summit of the cliff below Wheatcrofts and at Scarborough there is an outlying portion seen along the North Cliff.

Outliers of this rock occur also near Falsgrave and at Throxenby and there are a few isolated hills just at and north of the former which, judging from their height, may be capped with Cornbrash, but they are too thickly covered with drift to be sure about the matter, and no fragments of the rock were found on them.

Inland, the Cornbrash has only been seen at a few places, but its outcrop between the dry soil of the Kellaways Rock and the wet clays below is not difficult to trace.

LIST of CHARACTERISTIC CORNBRASH FOSSILS.

ECHINODERMATA.

Echinobrissus orbicularis, Phil.
Holectypus depressus, Lam.

BRACHIOPODA.

Rhynchonella concinna, Sow.
Waldheimiala obovata, Sow.
" *ornithocephala*, Sow.

LAMELLIBRANCHIATA.

Ostrea flabelloides, Lam.
Pecten lens, Sow.

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* Mr. Hudleston gives a list of the fossils from these shales.—Proc. Geol. Assoc., Vol. IV., p. 362.

† Mr. Leckenby informed me that he has obtained *Chemnitzia vittata*, *Actæonina Scarburgensis*, *Bulla undulata*, *Pecten demissus*, *Lima rigidula*, &c., undoubted Cornbrash fossils, from the extreme edge of the rocks close to low-water mark; but this must have been a slipped portion of the rock, and there does not appear to be any of it left now.

Pecten demissus, Phil.
„ *vagans*, Sow.
Lima duplicata, Sow.
Avicula echinata, Sow.
Pinna cuneata, Bean.
Modiola cuneata, Sow.
Trigonia Scarburgensis, Lyc.
„ *elongata*, Sow.
„ *Cassiope*, D'Orb.
Cardium cognatum, Phil.
Unicardium depressum, Phil.
Pholadomya angustata, Sow.
Homomya crassiuscula, Lyc. and Mor.
Goniomya v. scripta, Sow.
Myacites decurtata, Phil.
Gresslya peregrina, Phil.

GASTEROPODA.

Actæonina Scarburgensis, Lyc.
Amberlya armigera, Lyc.
Bulla undulata, Bean.
Chemnitzia vittata, Phil.
Littorina punctura, Bean.

CEPHALOPODA.

Ammonites Herveyi, Sow.

MIDDLE OOLITES.

Kellaways Rock.—Immediately above the dark shales of the Cornbrash there occurs in Yorkshire a great sandy deposit, which so long ago as 1824, was proved by William Smith and Professor Phillips to contain the same fossils as those of Kellaways Bridge in Wiltshire.

The Kellaways Rock of the Yorkshire coast is a thick-bedded soft sandstone, usually rather ferruginous, which gives it a brownish-yellow colour; in its upper portion there is a red calcareous band from which most of the fossils are obtained, the rest of the formation being almost entirely unfossiliferous; towards the base the beds become more argillaceous, and pass by insensible gradations into the blue shale of the Cornbrash Clays.*

The Kellaways Rock is first seen immediately south of the Cornbrash shale at Newbiggin Wyke, where at low water it forms a projecting reef; it is here scarcely 6 feet in thickness, but rapidly thickens out westwards to about 30 feet in Gristhorpe Cliff, and as much as 75 feet in the North Cliff at Scarborough: At the western end of Gristhorpe Bay the outcrop is obscured by drift for some distance until it juts out high up in the cliff immediately east of the great Red Cliff Fault; from here the sandstone is thrown down and is seen on the shore at the southern end of Cayton Bay, where it has much weathered away along the lines of joints, which gives this part of the cliff a peculiar appearance like a row of buttresses. The rock appears again on the shore at the northern end of the bay and in the summit of the cliff below Wheatcrofts, where it has been quarried; from this last the outcrop extends inland and can be easily traced by the projecting feature it makes on the sides of the hills west of Scarborough.

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* The Kellaways Rock has been described in detail by Leckenby, Quart. Journ. Geol. Soc., Vol. XX., p. 4; and Hudleston, Proc. Geol. Assoc., Vol. IV., p. 363.

There are a few outlying portions of the Kellaways Rock at Scarborough and a short distance west of the town. On the north cliff at Scarborough the rock is well exposed, but its outcrop is much disturbed by the faults at the castle,* beyond which it dips seawards and is last seen in the low water scars at the northern and southern points of the hill.

The Kellaways Rock has been quarried at Wheatcrofts, Rowbrow Wood, Ayton Forge, and several other places.

Kellaways Rock Fossils.

Brachiopoda.

Rhynchonella Thurmanni, Voltz.
Waldheimia ornithocephala, Sow.

Lamellibranchiata.

Ostrea flabelloides, Lam.
Gryphæa dilatata, Sow.
Pecten fibrosus, Sow.
Avicula inæquivalvis, Sow.
Modiola bipartita, Sow.
Trigonia paucicosta, Lyc.
Cardium cognatum, Phil.
Anatina undulata, Sow.
Goniomya literata, Sow.
Myacites recurvus, Phil.
„ *calceiformis*, Phil
Gresslya peregrina, Phil.

Gasteropoda.

Pleurotomaria guttata, Phil.

Cephalopoda.

Ammonites modiolaris, Lhuid.
„ *Kœnigi*, Sow.
„ *athleta*, Phil.
„ *alligatus*, Bean.
„ *Gulielmi*, Sow.
„ *Gowerianus*, Sow.
„ *lunula*, Zeit.

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* *Vide* p. 40.

Oxford Clay.—This formation is lithologically very unlike its equivalent in the south of England, and if it were not for the fossiliferous horizons both above and below, it would have been difficult to correlate this grey sandy shale with the dark blue clay of the south.

These shales first appear in the cliff north of Filey, near the spot called on the Ordnance map "White Stones," and can be easily traced westwards some way along Gristhorpe Cliff; they again appear beyond the fault at Red Cliff, where they occupy about a half of the total height of that cliff, and together with the sandstones above and below present one of the most magnificent sections on the Yorkshire coast.

At Scarborough Castle Hill the Oxford Clay is divided into two portions by the faults at that place, one of which is seen north of the drawbridge where the old Charnel House used to be, the other portion outcropping on the slopes of the hill below the Castle.

The thickness of the Oxford Clay, which on the coast varies from about 150 to 120 feet, decreases rapidly inland, but its outcrop is easily traced by the band of wet ground which it forms on the flanks of the hills west of Scarborough.

There are some small inlying portions of this clay in Beedale, Sawden Dale, at Ebberston, and in Thornton Dale.

The Oxford clay of Yorkshire has obtained but little notice from collectors, both on account of the paucity of its fossils and their bad state of preservation.

The following are some of the species found in this bed:—

FOSSILS of the OXFORD CLAY.

LAMELLIBRANCHIATA.

Gryphæa dilatata, Sow.
Pecten vagans, Sow.
Pinna mitis, Phil.
Avicula inæquivalvis, Sow.
Modiola bipartita, Sow.
Astarte carinata, Phil.
Pholadomya simplex, Phil.

GASTEROPODA.

Alaria bispinosa, Phil.
,, *trifida*, Phil.

CEPHALOPODA.

Ammonites cordatus, Sow.
,, *Lamberti*, Sow.
,, *Mariæ*, D'Orb.
,, *oculatus*, Phil.
Belemnites hastatus, Blain.
,, *Owenii*, Pratt.

Lower Calcareous Grit.—This, which is one of the principal rocks of this part of the Yorkshire coast, consists of a massive yellow calcareous sandstone becoming more shaly towards its lower portion. The upper part of the rock is marked by about 10 feet or more of soft sandy beds containing lines of silicious nodules which have weathered out from the main mass and form a very prominent object in the cliffs at Scarborough Castle and near Filey; these rest on a much harder bed, which, although only about 3 feet thick, stands out from the cliff in a well-marked ridge, and it is probably owing to the great regularity of this bed and its greater hardness that the tabular form of these hills in the interior is due*; below this comes the main mass of the Lower Calcareous Grit composed of rough reddish-yellow grits with silicious bands and nodules along certain lines, which becoming more argillaceous towards the base pass by insensible gradations into the Oxford Clay below.

Nearly 80 feet of this rock are seen in the cliff north of Filey, but further west the upper part has been removed by denudation from the cliff edge so that we do not get its full thickness. At Scarborough Castle it is nearly about the same thickness, but increases inland, and north of Allerston is fully 100 feet thick.

The Calcareous Grit, which first rises above the waters of the sea on the north side of Filey Brig, presents grand sections in the cliffs north of Filey, at Red Cliff, and at Scarborough Castle; from Cayton Bay the outcrop extends inland, and is remarkable for the line of bold headlands which it forms at Olive's Mount, Seamer Moor, and beyond. A few inlying portions of this rock crop up in the valleys west of Brompton and along the fault between Snainton and Wilton. The only outliers that come into this map are those of the Scarborough Castle Hill and the Hackness Hills.

There are a great number of quarries in this sandstone along the edge of the cliff and the inland escarpment, and also among the inliers at Allerston and in Thornton Dale: the beds when fresh quarried are usually rather soft, but by exposure to the atmosphere becomes harder and more durable. The Lower Calcareous Grit is so intimately connected palæontologically with the lower limestones of the Coralline Oolite, and these beds are so very dissimilar from the upper part of the formation, that we have classed the fossils in two groups; the lists are therefore indicative of a low and high position respectively rather than characteristic of any particular bed.†

FOSSILS of the LOWER CALCAREOUS GRIT and the CORALLINE OOLITE (Lower Portion).

ECHINODERMATA.

Echinobrissus scutatus, Lam.
Holectypus depressus, Lam.

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* William Smith, "the Father of English Geology," suggested this fact in his "Stratification of the Hackness Hills." MS. in the possession of R. Turnbull, Esq., Hackness.

† *Vide* Blake and Hudleston, Quart. Journ. Geol. Soc., Vol. XXXIII., p. 260.

BRACHIOPODA.

Rhynchonella Thurmanni, Voltz.

LAMELLIBRANCHIATA.

Exogyra mima, Phil.
Gervillia aviculoides, Sow.
Gryphæa dilatata, Sow.
Ostrea flabelloides, Lam.
„ *solitaria*, Sow.
Pecten subfibrosus, D'Orb.
Pinna lanceolata, Sow.
Astarte Duboisiana, D'Orb.
Isocardia tenera, Sow.
Lucina obliqua, Buvig.
Modiola bipartita, Sow.
Pholadomya angustata, Sow.
Sowerbya triangularis, Phil.

GASTEROPODA.

Alaria bispinosa, Phil.
Cylindrites elongatus, Phil.
Dentalium entaloideum, Desh.

CEPHALOPODA.

Ammonites cordatus, Sow.
„ *perarmatus*, Sow.
„ *plicatilis*, Sow.
Belemnites abbreviatus, Mill.

The "Greystone" or Passage Beds.—These beds, which include the upper part of the Calcareous Grit and the lower portion of the Coralline Oolite, being in reality the passage between the two, we have mapped separately, partly on account of their peculiar lithological character and partly from the distinct physical feature which they form in their inland development.*

The central portion of these beds, which may be described either as a calcareous sandstone, or as an arenaceous limestone, is locally known by the name of "Greystone" and is extensively quarried in the western part of the map for building walls and road mending. It is a very hard siliceous rock exhibiting much falsebedding and splitting into slabs often of a considerable size; it does not appear to be much more than from 25 to 30 feet in thickness, but from its hard nature is capable of covering a somewhat large area to the north of Ebberston and Snainton. These beds pass down into a loose sand containing decomposed fragments of the rock which is evidently its residue, the lime having been dissolved out; on some of the more exposed localities, as Brompton and Troutsdale Moors, there is nothing left but the sand, while the springs which rise from them form large deposits of calcareous tufa in the valley below. The upper part of the rock becomes more calcareous and oolitic as it approaches the true limestone above, the passage being so gradual that no exact line can be drawn.

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* This subdivision has also been adopted by Mr. Hudleston in his various papers on these rocks.

At Filey there are a series of brown and grey gritty beds resting on the ball bed of the Lower Calcareous Grit which contain *Gervillia aviculoides*, *Rhynchonella Thurmanni*, &c. in great abundance, and which seem to occupy this horizon, but as their connexion with the outcrop inland is obscured by boulder clay it is only on palæontological evidence that we can establish their identity.

SECTION measured on the NORTH SIDE of the CARR NASE, FILEY.

			ft.	in.
		Boulder Clay resting on a denuded surface.		
UPPER LIMESTONE?	Oolitic Limestone.	Irregular rubbly Oolitic Limestone - - -	15	0
		White shelly Limestone partly oolitic, with *Ostrea mima*, *Ostrea duriuscula*, *Pecten vimineus*, *Pecten vagans*	2	0
		Fissile slabby beds - - - - - -	3	0
MIDDLE CALC. GRIT?	Filey Brig Calc. Grit.	Massive Sandstone with fucoids on top - -	2	0
		Shelly band containing *Serpula*, *Gervillia aviculoides*, *Pecten subfibrosus*, *Ostrea mima*, *Gryphæa dilatata*, *Chemnitzia Heddingtonensis* - - -	0	7
		Hard massive sandy Grit with *Gervillia aviculoides* and *Pecten subfibrosus* along certain lines - -	9	0
		Brown and yellow nodular Grit - - -	1	3
PASSAGE BEDS.	Grey Grits.	Hard grey Grit with irregular top containing *Serpula*, *Vermicularia*, *Avicula*, *Trigonia* - - -	0	6
		Brown and yellow Grit - - - -	2	0
		Hard irregular grey Grit - - - -	0	8
		Hard grey Grit - - - - -	1	0
		Nodular bed with comminuted shells - -	0	10
		Cherty oolitic bed almost pisolitic with fossils *Trichites Plottii*, &c. - - - -	0	10
		Oolitic bed with *Serpula*, *Ostrea mima*, &c. - -	1	3
		Grey gritty bed with small *Serpulæ* - - -	1	10
		Grey gritty bed with *Gryphæa dilatata*, lower and upper valve separate - - - -	0	10
		Pale greenish grey Grit - - - -	1	0
	Brown and Grey Grits.	Brown sandy bed - - - - -	2	6
		Grey Grit with *Rhynchonella Thurmanni* - -	2	6
		Grey Grit with *Rhynchonella Thurmanni* - -	2	0
		Grey Grit with *Gervillia aviculoides* - -	1	6
		Brown sandy Grit with *Gryphæa dilatata* - -	2	9
		Brown sandy Grit with *Pecten subfibrosus*, *Ostrea mima*, *Gervillia aviculoides* - - -	2	6
	Spongy porous Grits.	Rhynchonella bed with fucoidal base containing *Pecten subfibrosus*, *Gervillia aviculoides* - -	2	6
		Rhynchonella bed, *Rhynchonella Thurmanni* very abundant - - - - - -	1	0
		Spongy bed shaly at base with a band of *Gervillia aviculoides*, *Gryphæa dilatata* - - -	1	6
		Gervillia beds, *Gervillia aviculoides* very abundant -	2	0
		Hard grey Grit with *Pecten subfibrosus* and *Gervillia aviculoides* - - - - -	2	0
		Grey gritty bed full of *Serpula*, *Ostrea mima*, *Pecten subfibrosus*, and Plant remains - - -	1	0
		Soft sandy beds in three or four divisions with large sponge doggers, *Serpula lacerata*, *Pecten subfibrosus*, *Gryphæa dilatata*, *Ostrea mima* - - -	10	0
Lower Calcareous Grit.		Hard gritty Sandstone with doggers - -	2	0
		Massive Sandstone passing down into shaly Sandstone about - - - - -	50	0

At Scarborough these rocks are very accessible and can be easily examined on the north side of the Castle Hill where the upper portion is so full of *Gervillia aviculoides* as to well merit the name of "Gervillia beds."

SECTION measured on the NORTH SIDE of the CASTLE HILL, SCARBOROUGH.

			ft.	in.
		Boulder-Clay.		
Lower Limestone.		Oolitic Limestone in several beds with *Echinobrissus scutatus*, *Ostrea mima*, *Gervillia aviculoides*, and *Trigonia*	26	6
PASSAGE BEDS.	Grey Gervillia Beds.	Falsebedded Grit with small projections weathering black	4	0
		Soft sandy stone with ferruginous nodules	1	6
		Parting with *Pecten subfibrosus*	0	8
		Irregular spongy Grit with *Cylindrites*	1	0
		Soft bed with uneven base	0	6
		Fine grained grey spongy Grit with *Gervillia aviculoides*	2	0
		Fine grained hard grey Grit with *Gervillia aviculoides* and *Gryphæa dilatata*	3	0
	Yellow foxy Grits.	Yellow sandy Grit	1	6
		Yellow Grit	3	0
		White Grit passing down into massive spongy Grit with *Gervillia*, *Ostrea*, *Pecten*	5	0
		Yellow Grit with *Gervillia*	2	0
		Hard band of Grit	1	0
		Shaly band with *Pecten subfibrosus*, *Ostrea mima*	1	0
		Solid bed of Grit	2	0
		Six or seven courses of sandy yellow spongy rock with *Rhynchonella*, *Pecten subfibrosus*, *Trigonia*, *Ammonites cordatus*	7	0
		Yellow sandy Grit	2	6
		Bright yellow soft sands with silicious balls	18	0
		Hard massive Grit evenly jointed with a spongy line on top	3	0
		Massive Sandstone passing down into shaly Sandstone.		

In Thornton Dale these beds assume a more massive character and frequently stand out in a line of bold crags above the softer sandstone. They here consist of a silicious grit, with thin bands and lenticular patches of calcareous sandstone, which at Lockton, just beyond the western edge of the map, pass into hard blue calcareous beds full of fossils. The junction of these beds with the oolitic limestone above is much sharper and more distinct than it is to the east, and they form a well-marked feature on the sides of the hills in this neighbourhood. North of Ebberston and Brompton the Greystone is easily distinguished from the Coralline Oolite, but as we trace it eastwards the difference is not so marked and it becomes really the basement beds of that formation, and is not easily separable from the limestone above.

Along their outcrop, west of the Forge Valley, an immense number of shallow quarries have been opened in this stone, and in some parts there is a quarry in almost every field.

Coralline Oolite.—The Coralline Oolite of this part of Yorkshire is divisible into three series, consisting of two beds of oolitic limestone separated by a thin set of sandstones, or rather alternations of calcareous and arenaceous strata—the Middle Calcareous Grit.

The Lower Limestone.—The lower of these limestones when well developed is a massive thick-bedded rock, composed of minute oolitic grains with great numbers of fossils; when first quarried it is of a decidedly blueish hue, but becomes of an almost creamy whiteness on exposure to the air. This limestone has its greatest thickness in the west of the map, about Allerston and Thornton Dale, where it is extensively quarried and burnt for lime, but it rapidly thins away, both towards the north-west and south-east, and is not easily recognizable much beyond either High Dalby or Seamer. There are nearly 30 feet of this limestone on Scarborough Castle Hill, but its greatest development is to the west beyond the limits of the map; before reaching Filey it seems to disappear, the last indications of it being the oolite which is seen just below the Boulder-Clay on the cliffs above Newbiggin. This limestone is eminently distinguished by its fossils from the beds which lie above, but as we propose to enter into this subject more fully in the general memoir, we will merely mention that the commonest species are *Cylindrites elongata*, *Gervillia aviculoides*, *Pecten subfibrosus*, and a small *Ostrea*.

The Middle Calcareous Grit.—This rock occupies the principal area on the high moors above Dalby, although it has not so great a thickness within the area of this map as a little further to the west. A thin band also extends along the slope of the hill from Wydale eastwards, but its course in the neighbourhood of Seamer is very obscure, beyond which point to Filey Brig the outcrop is not traceable; in fact it is only upon palæontological evidence that the beds at Filey Brig can be correlated with this horizon.*

It is only in a few places that a section of this rock is seen, but from these imperfect exposures it appears to be composed of alternations of hard and soft sandstone with calcareous layers and possibly here and there a little true limestone.

At Mount Pleasant, near Brompton, the hard silicious beds are quarried for road metal.

This rock forms very dead cold land on the higher moors in the west of the map, and the change in vegetation from this land to the calcareous beds below is very sharp and well defined.

One peculiarity of this rock is the quantity of small holes or pits which are found scattered over the moors where it occupies the surface; at first sight these pits seem to be due to artificial means, but after the examination of a great number of them it would appear to be more probable that they owe their origin to a sinking of the strata by the dissolving away of the calcareous beds below.

The Upper Limestone.—The upper bed of limestone, although in its lower portion lithologically very similar to the lower bed of limestone previously described, assumes in its upper part a very different character, it is in fact a true Coral Rag having a peculiar rubbly aspect without a trace of bedding, being composed largely of crystallized carbonate of lime abounding with corals.

This limestone occupies the lower part of the slope between Brompton and Seamer, east of which it passes beneath the Boulder-

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* I am indebted to my friend Mr. Hudleston for drawing my attention more particularly to this point.

Clay, and is not traceable, although the limestones in the upper part of the section at Filey Brig are probably of this age.

In the well near Cayton belonging to the Scarborough Waterworks these beds were apparently passed through, but the several subdivisions are not clear. (*See* note, p. 41.)

WELL of the SCARBOROUGH WATERWORKS between Osgodby and Cayton.

	ft.	in.
Earth and clay - -	5	3
Brown clay - - -	19	6
,, ,, with Boulders	4	0
Sand and Gravel - -	6	0
Fine grey Sand - -	2	0
Ragged Limestone - - (commonly called "Roundheads")	5	6
Limestone with soft yellow gritty partings.	1	2
	0	0½
	1	4½
	0	0½
	1	2½
	0	0½
	1	10½
	0	1
	2	11
	0	1
	2	8
	0	1
	1	2
	0	0½
	2	2½
	0	2
	2	11
	0	1½
	0	11½
	0	1
	1	6
	0	0½
	1	8
	0	3
	1	2
Carried forward - -	66	1½
Brought forward -	66	1½
Limestone with soft yellow gritty partings.	0	1
	2	5
	0	1
	1	3½
	0	1
	2	10
	0	1
	1	2
	0	6
	1	0
	0	7
	2	5½
	0	0½
	1	5
	0	1
	1	8½
	0	0½
	2	2
	0	1
	0	10
	0	1
	0	8½
	0	0½
	1	8½
	0	2½
	2	6
	0	2
	1	6
	0	10
	0	2
Carried forward -	93	0
Brought forward -	93	0
Limestone with soft yellow gritty partings. This part of the stone is of a dark blue colour and very strong.	1	4
	0	3
	1	6
	0	4
	1	0
	0	0½
	5	2½
	0	4
	1	9
	0	3
	2	6
	0	3
	3	3
	0	0½
	3	5½
	0	6
	2	0
	0	3
	1	6
	0	6
	4	0
	0	3
	3	6
	0	6
	2	6
	0	4
	3	6
	0	2
	3	0
Shale - - -	0	6
Total - - -	138	6

In this section the whole of the rock has been marked as limestone, but Mr. Arundel, who sank the well, informs me that it is similar to that forming the Castle Hill at Scarborough. It is probable that nearly the whole thickness of the Coralline Oolite and Calcareous Grit were pierced in this well, but without further information it is impossible to draw any line between them.

West of Brompton the Upper Limestone has been removed from the summit of the hills, but a few small patches have been brought down and preserved between the faults at Hazel Hall, Ebbertson, and Allerston.

The crystalline, or Coral Rag, portion is extensively quarried as a road material, but it is only the oolitic beds which are burnt for lime.

The Upper Limestone is characterised in its lower part by the abundance of gasteropoda, *Chemnitzia Heddingtonensis*, *Phasianella striata*, &c. and in its upper portion by the great quantity of corals it contains, *Thecosmilia annularis*, *Thamnastræa concinna*, and *Cladophyllia Conybearii.* Spines of *Cidaris florigemma* are also especially abundant in this limestone.

The thickness of the Coralline Oolite varies considerably in its range across the map, and it is only in the neighbourhood of Brompton that we appear to get the complete series. The full thickness at this place cannot be less than 90 or 100 feet, but east of this the lower beds gradually thin away, while on the west the higher portion does not outcrop.*

FOSSILS of the CORALLINE OOLITE (Upper Portion), including the CORAL RAG.

ACTINOZOA.

Cladophyllia Conybearii, M. Edw.
Rhabdophyllia Edwardsi, M'Coy.
Thamnastræa concinna, Goldf.
Thecosmilia annularis, Flem.

ECHINODERMATA.

Cidaris florigemma, Phil.
,, *Smithii,* Wr.
Echinobrissus scutatus, Lam.
Holectypus depressus, Lam.
Pseudodiadema versipora, Phil.

LAMELLIBANCHIATA.

Ostrea duriuscula, Phil.
Pecten vimineus, Sow.
,, *fibrosus,* Sow.
Lima elliptica, Whil.
,, *rigida,* Sow.
Astarte ovata, Smith.
Lucina Beanii, Lyc.
,, *obliqua,* Buvig.
Trigonia perlata, Ag.
,, *costata,* Park.
,, *clavellata,* Park.

GASTEROPODA.

Chemnitzia Heddingtonensis, Sow.
Littorina muricata, Sow.
Nerinæa fasciata, Voltz.
Phasianella striata, Sow.

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* Professor Phillips estimated the thickness of this bed at about 60 feet, but he does not appear to have observed the Middle Calcareous Grit, or to have noticed the distinction between the two beds of limestone.

CEPHALOPODA.

Ammonites cordatus, Sow.
„ *plicatilis*, Sow.
„ *varicostatus*, Buckl.

The Upper Calcareous Grit.—As the junction of the Coralline Oolite with the beds above has not been observed anywhere in the district we are unable to say if the Upper Calcareous Grit occurs in the map. This Grit is first seen just west of Thornton Dale, so that it is very probable that it exists below the Kimeridge Clay about Allerston and Ebberston if not further east.

UPPER OOLITES.

Kimeridge Clay.—The Kimeridge Clay, which really occupies almost the whole of the low ground in the centre of the map, is, with the exception of a few indistinct sections, entirely concealed by the glacial and post-glacial deposits of the great central valley; it only actually comes to the surface on the steep slopes of Thorpe Basset Wold, in a narrow strip west of Brompton and in a few variable sections in the cliffs and foreshore of Filey Bay, which latter are only visible under certain states of wind and tide. As far as these very imperfect sections allow, it appears to be a dark blue shaley clay with septaria and thin bands of limestone full of fossils. The shale itself when met with at any depth in wells or boreholes is very hard and difficult to penetrate.

The thickness of the Kimeridge Clay cannot be ascertained with any exactitude as there is no evidence of a constant dip, but it is certain that it must be considerable as in a borehole sunk at Knapton 500 feet of blue clay were pierced without finding the bottom of it.

The following section, which is one of the deepest of those of which we have been able to obtain a more detailed account, affords some insight into the nature of this formation:—

BOREHOLE at KNAPTON LODGE.

	ft.	in.
Sand	30	0
Yellow clay	30	0
Black shale	40	0
Blue clay	40	0
Kimeridge clay * (shale with fossils); a little water here	130	0
Oolite clay * (very black clay)	30	0
Yellow rock (sandstone with fossils)	1	0
Kimeridge clay*	18	0
Yellow rock; lost the water	1	0
Total	320	0

The water was salt, but it does for cattle; it rose 10 feet above the surface.

This clay was formerly used for making bricks, &c. at Allerston and near Thorpe Basset, but these works are now abandoned, and at the present time it is not anywhere in this district used for economic purposes.

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* These are the names given by Mr. Owston, who sank the well, and to whom we are indebted for the above particulars.

The following list of Kimeridge Clay fossils are recorded from this part of Yorkshire :—

ECHINODERMATA.

Pentacrinus, sp.

BRACHIOPODA.

Rhynchonella inconstans, Sow.
Lingula ovalis, Sow.
Discina latissima, Sow.

LAMELLIABRANCHIATA

Gryphæa nana, Sow.
Exogyra virgula, Defr.
Pinna granulata, Sow.
Modiola bipartita, Phil. non Sow.
Leda, sp.
Thracia depressa ?, Sow.
Ceromya excentrica ?, Ag.
Myacites, sp.
Pholadomya, sp.

CEPHALOPODA.

Ammonites alternans, Von Buch.
„ *Berryeri ?*, Leseur.
„ *biplex*, Sow.
„ *longispinus*, Sow.
„ *Marantianus*, D'Orb.
„ *mutabilis*, Sow.
„ *rotundus*, Sow.
„ *triplicatus*, Sow.
„ *Yo ?* D'Orb.
Belemnites Trosloyanus, D'Orb.

REPTILIA.

Ichthyosaurus, sp.

Portland Beds.—The Portland Beds are represented in Yorkshire by a band of coprolites with Saurian remains, below which are a few feet of dark-coloured clay containing the characteristic ammonites, viz., *Ammonites gigas*, Zeit., *Ammonites Gravesianus*, D'Orb., and a few other forms.

The top of these beds is clearly marked in the lower part of New Closes Cliff by the old workings of coprolites, but the lower portion is only occasionally exposed on the shore near this place when it has been bared by heavy storms ; it is also sometimes seen opposite Reighton Gill where it has been brought down by a roll of the strata.*

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* The strata at these places were not exposed during our survey, and I am indebted to my friend Mr. Leckenby for tracing their outcrop on the shore, and particularly to Mr. Judd's valuable papers for most of the above particulars.—Quart. Journ. Geol. Soc., Vol. XXIV., p. 218, and Vol. XXVI., p. 326.

A bed of phosphatic nodules below clays containing Lower Neocomian fossils found at Knapton, mark the inland extension of these beds.

LOWER CRETACEOUS.

Neocomian Clays.—To my friend and former colleague, Mr. Judd, is due the great merit of having been the first to carefully work out and map the details of this formation, and after a critical examination of several collections of Specton fossils to determine its true age and its precise relations to equivalent beds both in England and on the continent.

The strata which are exposed in Filey Bay have long occupied the attention of geologists; so early as 1822 these beds were described, and a few of the fossils figured by Young and Bird, who gave them the name of "the Upper Shale" and since that date a number of other papers have appeared relating to the same subject.*

The Neocomian Clays, to which Mr. Judd assigns a thickness of about 500 feet, and which judging from the dip is probably about right, unless higher beds are hidden below the Chalk on the south side of the fault, consist of a great mass of black and grey shales with a band of cement stones near the upper part and a band of phosphatic nodules at the bottom.

The frequent slipping of the cliff has much obscured and confused these beds, but it is possible by closely studying the section to separate them into distinct horizons. The upper of these, which is very black towards the top but becomes greyer in its lower part, forms the ridge between the Old Beck and Black Cliff; the clays of this division are, with the exception of a few Belemnites almost devoid of fossils, but their base is clearly marked by a band of Septaria which has been worked for cement.

The middle division outcrops in the lower part of Black Cliff where it is much hidden by the landslip at that place; it is also seen in the upper part of Middle Cliff, and on the ridge between the two. The principal fossils of this horizon are ***Belemnites jaculum, Pecten cinctus, Meyeria ornata***, and ***Ancyloceras Duvalii.***

The lowest division outcrops along the lower part of Middle Cliff, and consists of clays very indistinctly seen, the base of which are marked by a band of phosphatic nodules which has been worked for coprolites.

Mr. Judd has divided the Lower Neocomian into three separate zones, each of them marked by a characteristic species of ammonite; ***Am. Speetonensis*** in the upper portion, ***Am. Noricus*** in the centre, and ***Am. Asterianus*** in the lower part.

Inland these bed are not anywhere exposed except in a few places below the Wold escarpment between Ganton and Knapton, where there are a few pits from which clay was dug in former years for brickmaking and for marling the sandy land below. These pits are not any of them used at the present time, and are every year becoming more obscure.

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* A list of these is given by Mr. Judd in his paper on the Specton Clay.

Lower Neocomian fossils are said to have been procured from the three pits which are situated immediately below the Chalk in the parish of Knapton, which clearly demonstrates the unconformable overlap of the Upper Cretaceous rocks at this point.

LIST of FOSSILS from the NEOCOMIAN CLAYS at SPEETON.*

ANNELIDA.

Vermicularia Phillipsii, Röm.

LAMELLIBRANCHIATA.

Exogyra sinuata, Sow.
,, *subsinuata*, Leym.
Pecten cinctus, Sow.
Nucula obtusa, Sow.
Isocardia angulata, Phil.
Panopæa Neocomiensis, Desh.

GASTEROPODA.

Alaria Parkinsoni, Phil.
,, *bicarinata*, Leym.

CEPHALOPODA.

Belemnites semicanaliculatus, Blainy.
,, *jaculum*, Phil.
,, *lateralis*, Phil.
Ammonites Deshayesii, Leym.
,, *Speetonensis*, Y. & B.
,, *Noricus*, Schlöth.
,, *Asterianus*, D'Orb.
Ancyloceras Duvalii, Léveillé.

UPPER CRETACEOUS.

The Red Chalk.—The White Chalk towards its lower part is split up into numerous pink and white bands, which, quite at the base, graduate into a well-defined bed of Red Chalk, with thin seams of red shaly marl and greenish white nodular bands.

SECTION measured in the CLIFF below SPEETON.

	ft.	in.
Chalk without flints, about - - - -	40	0
Grey chalk tinged with red - - - -	5	0
Grey chalk - - - - - -	55	0
Reddish band becoming thicker further on - -	3	0
Grey chalk - - - - - -	16	0
Mottled red and grey beds - - - -	4	6
Red chalk with marly bands - - - -	8	0
Grey chalk with marly bands graduating into red -	8	0
Space obscured by talus.		
Deep red chalk. *Bel. minimus* abundant, about -	30	0

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* This list includes only the common species; an exhaustive list is given by Judd.—Quart. Journ. Geol. Soc., Vol. XXIV.

This lower bed is the "Red Chalk of Speeton" to the outcrop of which in Norfolk Mr. Seeley gave the name of the "Hunstanton Limestone."

The exact geological horizon which the Red Chalk should occupy has for some time given rise to much discussion among palæontologists,[*] some authors referring it to the Gault, some to the Upper Greensand, and others, again, to a combination of both formations, but as the weight of evidence seems to be in favour of the former, we have adopted that colour for our maps.

The Red Chalk is first seen at the base of the high cliffs three quarters of a mile east of Speeton Gap, from which point it gradually rises in the cliff towards the west until about 20 feet of it are seen; beyond this it is much obscured by the great landslip which has taken place, but its position must be some little distance up in the cliff, as the black Neocomian Clays are seen coming out below. It is again seen in the Old Beck, from which point it does not again appear at the surface for a distance of ten miles, although it has been proved in a well near Folkton to be 117 feet below the surface; and Young and Bird, in their "Survey of the Yorkshire Coast," also mention that the Red Chalk was met with in a borehole sunk in a deep dale a mile and a half south of Staxton at a depth of nearly 288 feet. Near Ganton the Red Chalk is seen at Windle Beck and in the old clay pits near Potter Brompton.

On the slope of the hill above Heslerton Grange a borehole has been recently sunk which shows the following section :—

Chalk - - - -	50
Red Clay - - - -	25
Black Clay - - -	92
(base not reached.)	
Total -	167

From this point westwards the Red Chalk is seen at several places, and where not seen the horizon is easy to trace by the aid of the springs thrown out by the underlying clay.

LIST of FOSSILS from the RED CHALK of YORKSHIRE, including those found in the alternating Beds above.

RHIZOPODA. (*Foraminifera.*)

Cristellaria rotula, Lam.

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[*] Rose, "On the Geology of West Norfolk;" Phil. Mag., 1835, Vol. VII., p. 180. Seeley "On the Red Limestone of Hunstanton;" Ann. and Mag. Nat. Hist., 1861, Vol. VII., p. 233. Wiltshire, "On the Red Chalk of England;" Geologist, 1859, Vol. II., p. 267. Judd, "Strata which form the base of the Lincolnshire Wold;" Quart. Journ. Geol. Soc., Vol. XXII., p. 249. Wiltshire, "Red Chalk of Hunstanton;" Quart. Journ. Geol. Soc., Vol. XXV., p. 185. Meyer, Geol. Mag., Vol. VI., p. 13. Blake, Geol. Mag., 2nd Dec., Vol. I., p. 362, and Proc. Geol. Assoc., Vol. V., p. 232. Cole, Proc. York. Geol. Soc., New Series, Vol. VII., p. 30.

ECHINODERMATA.

Cidaris Gaultina, Forbes.
* *Discoidea cylindrica*, Lam.
* *Holaster subglobosus*, Leske.
* *Peltastes stellulatus*, Ag.
* *Pentacrinus Fittoni*, Aust.

ANNELIDA.

Serpula solitaria, Phil.
Vermicularia umbonata, Sow.
* ,, *concava*, Sow.
,, *elongata*, Bean.

CRUSTACEA.

(*Cirripedia*).
Pollicipes unguis, Sow.
(*Ostracoda*.)
Cytherella ovata, Röm.

POLYZOA.

Ceriopora spongites, Gold.
Proboscina dilatata, D'Orb.

BRACHIOPODA.

* *Kingena lima*, Defr.
Magas pumila, Sow.
* *Rhynchonella lineolata*, Phil.
,, *Mantelliana*, Sow.
Terebratula biplicata, Sow.
,, *semiglobosa*, Sow.
* ,, *capillata*, D'Arch.
* ,, *Dutempleana*, D'Orb.
Terebratulina rigida, Sow.
,, *striata*, Wahl.

LAMELLIBRANCHIATA.

Avicula gryphæoides, Sow.
Inoceramus læviusculus.
* ,, *tenuis*, Mant.
* ,, *sulcatus*, Park.
Ostrea canaliculata, D'Orb non Sow.
,, *Rauliniana*, D'Orb.
* ,, *vesicularis*, Lam.
,, *vesiculosa*, Sow.
Pecten Beaveri, Sow.
* *Plicatula sigillina*, Wood.
Spondylus gibbosus, D'Orb.

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* These species are mentioned by Barrois, "Recherches sur le Terrain Crétacé Supérieur." Lille, 1876.

CEPHALOPODA.

Belemnites alternatus, Sow.
„ *Listeri*, Phil.
„ *minimus*, Mill.
„ *ultimus*, D'Orb.

REPTILIA.

Tooth of Saurian.

White Chalk.—The whole of the high ground in the south of the maps is composed of White Chalk. This district, which is the northern portion of the Yorkshire Wolds, forms a bold escarpment to the north, which is very well shown by the line of dark shading on the Ordnance map, extending from the neighbourhood of Rillington by Sherburn, Folkton, and Hunmanby to the sea-cliffs at Speeton, and from thence eastwards to Flamborough Head in a line of bold cliffs which attain a height of over 440 feet.

The White Chalk of Yorkshire is of a much harder and more flaggy nature than that of the south of England, and differs from it also in this respect, that, whereas in the southern counties the upper portion of the Chalk is noted for the great quantity of flint it contains, in Yorkshire it is just the reverse, the lower portion, although not quite the lowest beds, abounding in layers and nodules of flint, while those above are nearly destitute of that mineral. This feature of the Yorkshire Chalk is rendered very apparent by a comparison of the sea-cliffs on the north with those on the south of the headland of Flamborough; the lofty cliffs of Speeton, Buckton, and Bempton abounding in flint, while those of Sewerby contain but little, if any; the same is also observable with respect to the inland development of the Chalk, the northern portion of the Wolds westwards from Hunmanby being very flinty and with scarcely any good soil, while the district south of the great Wold valley by Twing, Rudstone, and Boynton has but little flint, and forms a deeper and more loamy soil.

Besides the layers of flint, the Chalk has also numerous bands of clay, often of a deep blue colour when met with at any depth from the surface, as shown in the sections below:—*

WELL at HELPERTHORPE, opposite the Public House.

	ft.	in.
Old well - - - - -	80	0
Chalk - - - - -	12	0
Blue Flint - - - - -	5	0
Clay (blue) - - - -	0	6
Little water obtained here.		
Chalk - - - - -	20	0
Flint - - - - -	4	0
Blue Clay - - - - -	1	0
More water obtained here.		
Chalk - - - - -	9	0
Plenty of water obtained.		
Total -	131	6

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* Mr. Mortimer mentions a similar clay as occurring at Driffield, and gives a chemical analysis of it. Quart. Journ. Geol. Soc., Vol. XXXI., p. 111.

WELL at WEAVERTHORPE, opposite the Post Office.

	ft.	in.
Old well	81	0
Chalk	20	0
Blue Clay	0	6
Plenty of water obtained.		
Total	101	6

WELL at BUTTERWICK.

	ft.	in.
Chalk	94	0
Flint	6	0
Clay	0	6
Water rose from here 3 feet above the surface.		
Chalk	17	0
Clay	2	0
Water rose from here 5 feet above the surface.		
Total	119	6

It is probably these argillaceous bands which throw out a few springs here and there over the chalk area, and which in a few situations, as that at Butterwick, give rise to artesian wells.

The chalk frequently exhibits a peculiar striated appearance, the origin of which has given rise to much discussion; these striations much resemble that known as "slickensides," and in some cases may be produced by the sliding of surfaces over one another. They usually occur where the Chalk is much disturbed and has been subjected to pressure, and seem to be the result of a fibrous structure in the Chalk itself; the transverse sections of the rock which are exposed in the blocks on the shore below Speeton, and which exhibit this structure spreading in various directions, might with advantage be studied by anyone interested in this matter.*

FOSSILS from the WHITE CHALK of YORKSHIRE.

SPONGIDA.

**Amorphospongia globularis*, Reuss.
Cephalites Benettiæ, Mant.
Chenendopora convoluta, Phil.
Coscinopora globularis, Phil.
„ *lævis*, Phil.
„ *pileolus*, Lam.
„ *porosa*, Phil.
Hippalimus radiciformis, Phil.
Manon marginatum, Phil.
„ *osculiferum*, Phil.

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* *Vide* Mackie; Geologist, 1860, p. 77. R. Mortimer; Quart. Journ. Geol. Soc., Vol. XXIX., p. 417. H. G. Fordham; *ibid.*, Vol. XXX., p. 43. Dr. Ogier Ward; *ibid.*, Vol. XXXI., p. 113.

Scyphia cribrosa, Phil.
Siphonia terebrata, Phil.
Spongia capitata, Phil.
,, *plana*, Phil.
* ,, *radiciformis*, Phil.
,, *ramosa*, Mant.
* *Ventriculites alcyonoides*, Smith.
,, *multicostatus*, Röm.

ACTINOZOA.

* *Caryophyllia cylindracea*, Reuss.
Parasmilia centralis, Mant.
,, *monilis*, Dunc.

ANNELIDA.

* *Vermicularia umbonata*, Sow.

ECHINODERMATA.

* *Bourgueticrinus*, sp.
,, *ellipticus*, Mill.
* *Cidaris dissimilis*, Forbes.
* ,, *hirudo*, Sorig.
* ,, *sceptrifera*, Mant.
* ,, *subvesiculosa*, D'Orb.
* ,, *vesiculosa*, Gold.
* *Cyphosoma*, sp.
,, *Königi*, Mant.
* *Discoidea cylindrica*, Ag.
Echinoconus albogalerus, Klein.
,, *subrotundus*, Mant.
Ananchytes ovatus, Leske.
Holaster hemisphæricus, Phil.
,, *planus*, Mant.
* ,, *subglobosus*, Leske.
Marsupites ornatus, Mil.
Micraster cor-anguinum, Leske.
* *Pseudodiadema*, sp.

BRACHIOPODA.

Kingena lima, Defr.
* *Rhynchonella lineolata*, Phil.
* ,, *Martini*, Mant.
* ,, *plicatilis*, Sow.
Terebratula carnea, Sow.
* ,, *semiglobosa*, Sow.
* ,, *squamosa*, Mant.
Terebratulina striata, Wahl.
,, *gracilis*, Schlot.

LAMELLIBRANCHIATA.

**Avicula gryphæoides*, Sow.
Dianchora striata, Sow.
Inoceramus Brongniarti, Sow.
„ *Cuvieri*, Sow.
„ *mytiloides*, Sow.
* „ *striatus*, Mant.
**Ostrea vesicularis*, Lam.
**Plicatula inflata*, Sow.

CEPHALOPODA.

Ammonites peramplus, Sow.
* „ *varians*, Sow.
Baculites baculoides, D'Orb.
**Belemnitella mucronata*, Blain.
* „ *quadrata*, Defr.
Crioceras Williamsoni, Phil.
Scaphites, sp.

SUPERFICIAL DEPOSITS.

Old Chalk Gravel.—This is the oldest of the superficial beds with which we have to deal; it is mainly composed of large fragments of water-worn chalk having much the aspect of an old shore deposit. This gravel is seen at several places along the cliff-edge from Flamborough Head southwards, but the best sections are those at South Sea and Danes Dyke, just beyond the limits of the map. It rests directly on the denuded surface of the Chalk occupying old valleys and depressions in that formation, and being everywhere covered by Boulder-Clay or Gravel it is not seen anywhere except in the coast-sections.†

Boulder-Clay and Gravel.—Along the whole of the coast section from Flamborough Head northwards the cliffs are either capped or wholly composed of Boulder-Clay and Gravel. This vast accumulation of clay and stones hugs the coast in a most striking manner, and does not extend on an average more than two miles inland.

On the higher cliffs, as about Buckton and north of Filey, it varies from 25 to about 75 feet in thickness, but in the low grounds where it probably lies in the courses of old valleys it is of immense thickness; thus at Filey and near the Spa at Scarborough it occupies the whole cliff, and there is at least 150 feet of it. At the Grand Hotel a well was sunk not far above high-water mark which penetrated about 100 feet of clay and stones before the solid strata were reached, so that at this place there must be 200 feet of Boulder-Clay filling an old valley the base of which must have been nearly 100 feet below the present sea level.

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† *Vide* paper by S. V. Wood and J. L. Rome; Quart. Journ. Geol. Soc., Vol. XXIV., p. 146.

Inland there is a little more than 30 feet of clay and sand at the Scarborough Waterworks near Osgodby,* and 22 feet of "good clay" in the brickyard at Musham Banks, while at the old Seamer brickfield there was not more than 3 to 6 feet of clay, but a considerable thickness of gravel was found below this.

The inner edge of this strip of drift over the Chalk area thins away very gradually, and it is not possible to mark its boundary with great exactitude. West of Hunmanby a thin covering extends for some little distance on to the Wolds, and there is a little Boulder-Clay and Gravel on Seamer Moor just north of the race-course.

Throughout the whole of its range the Boulder-Clay is intimately associated with beds of stratified sand and gravel, and it is frequently very difficult to say whether these belong to that deposit or are of a later date. They are seen in the coast sections of Filey Bay and at Scarborough, and inland at Reighton, Hunmanby, Muston, Gristhorpe, and other places.

Just north of Thornwick Cottage near Flamborough there is a pit in stratified gravel containing fragments of shells apparently below Boulder-Clay, but the section was not very distinct. There are also some outlying patches of sand on Willerby Wold and on Seamer Moor which may be of this age.

The Boulder-Clay has been dug for brickmaking at several places, but it is now used only at Hunmanby, Filey, Musham Banks near Seamer, and Wheatcrofts near Scarborough.

Sands and Gravel (*Estuarine and Sub-aërial*).—We now come to the superficial deposits of the Vale of Pickering, all of which mark a more recent epoch than those we have been describing. On either side of the great valley, which occupies the centre of the map, there are seen rising on the flanks of the hills certain sands and gravels which, although wholly unlike each other in their included fragments, were probably formed by the same agent and at the same time.

At the foot of the Chalk escarpment along its whole range in this map west of Flotmanby there is a thick covering of sand including angular and partially rounded fragments of chalk and chalk flints. These sands, which have been sunk through in a number of boreholes, are from 30 to 50 feet thick; and frequently in sheltered situations where there is a slight bend in the Wold escarpment, run up above their ordinary level as if they had been collected by the agency of the wind.

On the north side of the valley these beds are represented by finely stratified gravels composed of sand and waterworn pebbles of oolitic rocks of the immediate neighbourhood, and contain a great number of shell fragments. At Wykeham, Hutton Bushel, and Ayton these gravels form a well-marked terrace the summit of which is about 225 feet above the sea level; there are also indications of a second terrace at about 140 feet, and possibly a third below this, but they are not so distinct as the upper one, and become mingled with the sand and gravel of the rest of the valley. It is probable that these gravels are the remains of an old raised beach, as they occur some little distance above the level of the watershed near Filey, and exactly opposite to what would have been the entrance to this valley when it was an arm of the sea.

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* *Vide* p. 20.

Both the sands on the south and the gravels on the north side of the valley are formed almost entirely of fragments derived from the rocks against which they abut, proving the entire local nature of the agent by which they were deposited.

On the side of the chalk hill just south of Knapton there is a pit which exhibits about 30 feet of gravel composed entirely of angular chalk fragments without any sand, and has very much the appearance of the débris that would be found at the foot of an old chalk cliff, being probably formed at the same period as the sands and gravels in the valley below. One peculiarity in this pit is the well-marked lines of stratification which dip into the hill at an angle of 55°; this dip, which is in the opposite direction to that which would have been expected if the gravel were really the talus at the bottom of a cliff, seems to have been caused by the whole mass having slipped since its deposition, the chalk below dipping in the same direction at an angle of 70°.

Warp and Lacustrine Clay.—Immediately associated with these sands and gravels are the clays and alluvium which occupy the remainder of the valley. They appear to have been formed partly before and partly since the beds we have just been describing, and may in great measure have been deposited at the same time. They are in this district chiefly exposed at the surface in the great flats south of the villages of Wilton, Allerston, Ebberston, and Snainton, and are also found in the numerous boreholes along the line of railway, and at other places. At Brompton, where this clay is worked for brick-making, it is well laminated and appears to pass under the gravel to the east, although the section was not very clear.

The following sections obtained from wells and boreholes which have been sunk for water at various places, afford an insight into the post-glacial structure of this valley :—*

Wilton, about a mile south of the village.

	ft.	in.
Muck	30	0
Fine clay	40	0
Gravel		
Total	70	0

Allerston Ings.

	ft.	in.
Gravel, sand, and light clay (Some water obtained here.)	30	0
Black shale	120	0
Total	150	0

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* I am indebted for these sections, and also for several others in this and other parts of the county, to Mr. J. Kirkby of York, and Mr. Owston of Scarborough.

Skelton Wath House.[*]

	ft.	in.
Sand	7	6
Clay	4	0
Sand with water	9	0
Clay	2	6
Sand	6	0
Clay	49	0
Gravel	1	0
Total	79	0

Plentiful supply of water obtained, which rose 6 feet.

Scampston Hall.

	ft.	in.
Soil	4	0
Quicksand (red)	16	0
„ (dark)	10	0
„ and gravel	9	0
Sand and gravel	2	0
Quicksand (dark)	3	0
Soft clay	2	0
Hard clay	68	0
Gravel	0	3
Fuller's earth clay[†]	36	0
Sand	0	4
Total	150	7

Knapton Cottages.

	ft.	in.
Soil sand	4	0
Quicksand	13	0
Clay	3	0
Quicksand	4	0
Soft clay	67	0
Gravel	4	0
Total	95	0

Knapton Hall.

	ft.	in.
Soil sand	4	0
Clay	1	0
Quicksand	9	0
Clay	4	6
Quicksand	7	6
Soft clay	73	0
Gravel	6	0
Total	105	0

---

[*] This section was kindly furnished by Mr. Harland, of Sawdon Park Cottage, who also informs me that a well sunk at Crake Hall was very similar to that at Skelton Wath House.

[†] This clay is probably part of the Kimeridge Clay.

Knapton Lodge.

	ft.	in.
Sand	30	0
Yellow clay	30	0
Black shale*		
Total of superficial deposits	60	0

Knapton Lodge (112 yards from the one above).

	ft.	in.
Sand	30	0
Yellow clay	30	0
Sand and gravel	5	0
Total	65	0

Good water found here, which rose 4 feet above the surface.

Low Farm, Knapton.

	ft.	in.
Sand	35	0
Fine yellow clay	64	0
Sand and gravel	1	0
Total	100	0

Water rose 20 feet above the surface.

Yedingham, West Side of the York Road where the Heslerton Road branches off.

	ft.	in.
Soil sand	7	0
Clay	3	0
Quicksand	10	0
Clay	2	0
Quicksand	8	0
Soft clay	72	0
Gravel	5	0
Total	107	0

Yedingham, opposite Middle Flat.

Nearly the same as the above. Total about 107 feet.

West Heslerton Carr House (East Side of Road).

	ft.	in.
Sand	30	0
Yellow clay	29	0
Total	59	0

Water obtained, which rose 15 feet above the surface.

---

* This section is given complete on p. 22.

West Heslerton Carr House (West Side of Road).

	ft.	in.
Sand	42	0
Clay	18	0
Total	60	0

Water rises 15 feet above the surface.

West Heslerton Station.

	ft.	in.
Sand and gravel	35	0
Fine clay	12	0
White gravel with water	2	0
(Hard black clay below.)		
Total	49	0

Foulbridge.

	ft.	in.
Sand	30	0
Fine yellow clay	81	0
Gravel with water		
Total	111	0

Water rose 30 feet above the surface.

East Heslerton Carr House.

	ft.	in.
Sand and gravel	50	0
Fine clay	44	6
Gravel (white)		
Total	94	6

Plenty of water obtained here, which rose as high as the house.

Sherburn Station.

	ft.	in.
Black peat	5	0
Sand and gravel	36	0
Fine white clay with seams of sand	34	0
White gravel with water		
Total	75	0

Sherburn Cottages.

	ft.	in.
Black peat	5	0
Fine sand	45	0
Fine clay	40	0
Total	90	0

Water obtained, which rose 40 feet.

Ganton Station.

	ft.	in.
Fine sand	40	0
Fine clay	20	0
Hard black clay	10	0
Total	70	0

Binnington.

	ft.	in.
White gravel and sand - - -	45	0
Fine clay - - - - -	15	0
White chalk gravel - - -	0	4
Total	60	4

Water rose 6 feet above the surface.

Peat.—North of Sherburn and south of Wykeham, and also along the line of the dike called the New Hertford River between Willerby and Muston, there are several patches of dark peaty soil which towards the east increase in thickness and become a true peat. These patches, locally called "sulphur lands." were formerly mere swamps, but are now artificially drained and brought into cultivation, although they grow but inferior crops.

Gravel of dry Chalk and Oolitic Valleys.—The greatest beauty of the Chalk country are its winding ramifying valleys with their green slopes and graceful contours. The bottom of each of these valleys is almost always dry, and has a flat surface of gravel composed entirely of chalk fragments and flints, except towards the east, where the valleys drain from a drift-covered area, and where foreign pebbles are mingled with the débris of the chalk. These gravels, which are present in all the chalk valleys, and only vary in quantity according to the size of the valley and area of drainage, are best seen along the main Wold Valley by Weaverthorpe, Foxholes, Wold Newton, and North Burton, where they form a sandy flat nearly half a mile in breadth, and at Foxholes have a depth of about 40 feet, which probably increases to the east.

In a few of the small Oolitic valleys, more especially in Yedmandale, Brompton Dale, and some others, there is a deposit very similar to that just described. The bottoms of these valleys are filled with gravel and rubble derived from the Oolitic rocks of the immediate neighbourhood, which absorb all the water coming down the valley, so that no stream is visible at the surface.

Alluvium.—Of the usual form of river alluvium there is very little in these maps; those few of the Oolitic valleys which have streams in them usually have a narrow alluvial strip along their courses, and the lower part of the Derwent from Foulbridge westwards also has a narrow strip of this land which is chiefly devoted to pasture. The greatest spread, however, of modern alluvium is that which flanks the old course of the Derwent, between Ayton and Sherburn, and which differs somewhat from the ordinary kind of alluvium in that it has a higher level than the surrounding country. This deposit has evidently been formed by the river overflowing its banks during floods, for at the present time it is only kept within bounds by means of high artificial embankments, and a large part of the flood water, which is conducted by the New Cut into the sea north of Scarborough, is diverted from this channel altogether.

It is very curious to observe how the river in this part of its course, as it debouches from the gorge at Ayton, has raised its bed and flows along the most elevated part of the ridge which it has formed, the clay gradually thinning away on either side and overlapping the low lying peaty ground.

PHYSICAL STRUCTURE.—LIE OF THE ROCKS; FAULTS.

The general dip of all the strata is southerly, but there are several faults and local disturbances which we will now proceed to describe.

As mentioned above, there are three distinct physical areas, the Oolitic rocks along the north of the map forming hills which dip below the Kimeridge and Neocomian Clays of the valley, while these in turn pass beneath the escarpment of the Chalk Wolds.

Taking each of these areas separately we find that the Chalk has a general south-easterly dip of from 2 to 5 degrees, but there are so many lines of disturbance crossing it from east to west that the local dips shown on the map are as often to the north as they are to the south. These great lines of disturbance, which may arise in a certain measure from faults, and are probably more or less continuous, but from the want of more frequent sections it is impossible to say, have a general east and west direction. The principal line appears to start from the high cliffs north of Bempton, at that point marked on the map as Scale Nab,* where there is a magnificent section exhibiting highly contorted beds of Chalk, 250 feet in thickness; from this point the folds appear to run nearly due west, and are probably on the same line of disturbance as that which causes the high angles of dip seen in the railway cutting near Buckton Hall, near Bartingdale Plantation, north of Wold Newton, north of Foxholes, and near Hall Plantation, beyond which its course is very uncertain. South of Sherburn, near Haverdale Plantation, and immediately north of the village of Weaverthorpe, there are other lines of disturbed strata, some of which may be a continuation of the above; there are also small faults seen in quarries at numerous places, these are marked on the map, but from the nature of the formation they cannot be traced for any distance. The junction of the Chalk with the underlying clays is very obscure towards its eastern end; below Speeton and Reighton we have represented the junction by an uncertain line of fault, the principal evidence for which is obtained in the stream running down to the sea below the former village, where there are beds of red and white chalk resting against the thrown up and disturbed Neocomian Clays. There is a great undercliff of Chalk at this point, which much obscures the section, and which might cause the irregularity observed in the beck.

From Hunmanby northwards, the Chalk is again bounded by a line of fault which is seen in the railway cutting near the station, and which is probably the same as that at Red Cliff in Cayton Bay, where it has a downthrow to the west of over 100 feet.

---

* This place is locally known as "The Door."

West of Muston, the base of the Chalk, which is some considerable depth below the valley as proved in the well at Folkton,* is entirely hidden by superficial deposits as far as Ganton, near which are a few pits and sections showing red chalk resting on grey and blue clay; these sections are continued at intervals as far as Knapton, where, as we have said above, the lower beds of the Neocomian pass away under the Chalk and that formation reposes directly on the Kimeridge Clay. Immediately south of Wintringham we have not been able to obtain any direct evidence as to what the clay is, but on the western side of Thorpe Basset Wold, Kimeridge Clay fossils are found close under the chalk escarpment showing that here at least the Chalk has entirely overlapped.

From the want of good sections, we know very little about the general inclination of these clays; in Filey Bay the strata are subject to frequent rolls and contortions, but how far these extend inland we have no means of judging. About Allerston and Ebberston the black shale of the Kimeridge dips to the north at angles which increase from 5° to nearly vertical; this is caused by the large fault running nearly east and west which separates the Kimeridge Clay from the under-lying Oolites to the north. This fault is fully proved both by the relative position of these rocks and by the numerous boreholes that have been sunk along its course, all of which went through great thicknesses of shale in places where, but for the existence of this fault, the Calcareous Grit should have been found. The deepest of these boreholes was sunk just north of the road at the southern end of Wydale to a depth of 282 feet without reaching the bottom of the shale; this, by allowing for the amount of Oolite removed by denudation from the northern side of the fault, would give a minimum throw of 425 feet, and it may be a good deal more.†

The Limestones and Sandstones of the Middle Oolite rise gradually to the north and form a line of bold escarpments which extend along the coast from Filey Brig to Olivers Mount, and thence along the northern edge of the map to Troutsdale having two outlying portions at Scarborough and Hackness. The average dip of these beds is from 3 to 4 degrees to the south-east and they do not appear to be broken by any faults except the one mentioned near Ebberston with its several branches, and a few near the coast, which latter are all in a general north-east and south-west direction, and somewhat complicate the mapping near Scarborough. The most easterly of these is splendidly seen in the cliff at the southern end of Cayton Bay, where it has a throw of about 120 feet; the top of the Kellaways Rock on the east being on a level with the Calcareous Grit on the west; and it is interesting to observe how sharply the low water scars have been cut off by this fault. A little further on in the bay, near the pumping station of the Scarborough Waterworks, there is a second fault also with a downthrow to the west, which, although not seen in section at this place, is very apparent when the general lie of the rocks is viewed from the summit of Red Cliff; it has probably about the same amount of throw as that at Red Cliff, the base of the Calcareous Grit seeming to be about on a level with the top of the Kellaways Rock, but the section at the point of junction is entirely obscured by drift and land-slips. It is very likely the junction of this fault with the base of the Calcareous Grit which causes the copious spring at this place.

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* *Vide* p. 26.

† Deep boreholes have also been made in the clay between Ebberston and Allerston, the particulars of which are in the possession of Mr. John Brown, Rosehill, Chesterfield, who we are sorry has not thought proper to give any information respecting them. They were sunk to some considerable depth in search of coal, which, it is needless to say, was not found.

At the northern end of the bay a dislocation in the strata again appears, which, from its general direction, must be a continuation of that just described. This, which is seen in the cliff section on either side of Osgodby Nab, seems to be formed by two faults within a few feet of each other, the Millepore bed of the point being thrown against the Grey Limestone which a few feet further on is seen to be on a level with the Kellaways Rock, the united effect being that the Millepore bed on the east is placed on a level with the Kellaways Rock on the west, or equivalent to a throw of between two and three hundred feet. In Carnelian Bay, the low-water scars are much disturbed by this dislocation, and a channel has been formed in them which marks its course very distinctly.

At Scarborough there are two faults crossing the neck of land on which the Castle stands. These, which were originally discovered by William Smith, might easily be overlooked by a casual observer; they are best seen on the northern side below the Barbican, where a small portion not many feet in breadth is thrown up between two faults, so that the Kellaways Rock* is on a level with the Calcareous Grit, on either side, and the Cornbrash and Estuarine Series below with the Oxford Clay. Whether both of these faults are continued to the south is not very certain, the only evidence being that the rise of the Kellaways Rock from behind the harbour to St. Mary's Church is very sudden.

The fault near Seamer Moor House has not been seen anywhere in section, but its course is rendered evident in mapping the country by the irregularity observed in the beds on either side; thus to the south-east of Seamer Moor House there is a narrow strip of oolitic limestone thrown against the Calcareous Grit on the west, and near Throxenby there are two outlying portions of the Kellaways Rock which are, allowing for dip, at a much lower level than the main body of the rock in Rowbrow Wood. There are indications of this fault being continued to the south as far as Seamer Station, but the evidence is not sufficient to warrant it being so mapped.

There is along the northern edge of map an axis of upheaval ranging in an east and west direction, which, although not a line of fault, is intimately connected with such disturbances. This anticlinal axis, which appears to start from near Ramsdale Scar at Scarborough, strikes nearly east for the northern part of the nab formed by Seamer Moor, across the southern end of the Hackness Hill near Mowthorpe, along the northern part of Hutton Bushel and Wykeham Moors, across Troutsdale to High Dalby Moor, and thence on to the neighbourhood of Lockton. Along this line the strata roll over and have a northerly dip for a short distance until they meet an equally well-marked synclinal axis ranging through Hackness, which will be described in treating of that country.

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* Mr. Leckenby informs me that he has found *Ammonites Gowerianus* and other Kellaway forms in this uplifted portion.

NOTE.

Since the present Memoir went to press a well has been made in Cayton Village, of which the particulars are:—

	ft.	in.
Clay - - - - -	60	0
Limestone Rock - - - -	120	0
Hard blue Rock - - - -	20	0
Freestone - - - -	2	6
	202	6

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